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NATIONAL TRANSPORTATION SAFETY BOARD

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WASHINGTON, D.C. 20594

HAZARDOUS MATERIALS SPECIAL INVESTIGATION REPORT

COLLISION BETWEEN A TRACTOR-SEMITRAILER TRANSPORTING BOMBS AND AN AUTOMOBILE, RESULTING IN FIRE AND EXPLOSIONS CHECOTAH, OKLAHOMA AUGUST 4, 1985

NTSB/SIR-87/01

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16. Abstract About 3:30 a.m., c.d.t., on August 4, 1985, a tractor-semitrailer operated by Explosives Transports, Inc., and loaded with 10 MK 84 2,000-pound general purpose bombs, collided with an automobile on Interstate 40 near Checotah, Oklahoma. The automobile fuel tank ruptured and spilled gasoline which quickly ignited. Both vehicles were engulfed in flames. Subsequent explosions from the bombs destroyed the vehicles and left a crater in the roadway 27 feet deep and 35 feet across. Three hundred and seventy-one residences were damaged. Other buildings, including a school located 734 feet from the accident site, suffered substantial damage. Total damages were estimated at $5 million. Forty-nine persons reported to a hospital emergency room for treatment of injuries, most after breathing smoke and gases from burning tritonal. No one was fatally injured.

Safety issues addressed in this report concern the adequacy of the U.S. Department of Defense's (DOD) munitions transportation safety program, including procedures for identifying unsafe operating practices of motor carriers used to transport Class A and Class B explosive shipments; the lack of thermal protection for explosive shipments to provide reasonable time to evacuate persons from nearby threatened areas; and the adequacy of recommended minimum evacuation distances when explosives are involved in fire during transportation.

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As a result of its investigation, the Safety Board issued recommendations to the DOD to upgrade its munitions transportation safety program and to provide thermal protection for explosives shipments. The Safety Board issued recommendations to the Research and Special Programs Administration (RSPA) to require thermal protection for explosives shipments and to increase recommended minimum evacuation distances for explosives shipments involved in fire. The Safety Board reiterated recommendations to the Federal Highway Administration and the RSPA to eliminate ambiguities in the routing requirements for vehicles transporting hazardous materials, to encourage States to establish through routes for shipments of hazardous materials, and to coordinate the compatibility of the designated routes regionally and nationally.

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EXECUTIVE SUMMARY

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

HAZARDOUS MATERIALS SPECIAL INVESTIGATION REPORT

Adopted: March 3, 1987

COLLISION BETWEEN A TRACTOR-SEMITRAILER TRANSPORTING BOMBS AND AN AUTOMOBILE, RESULTING IN FIRE AND EXPLOSIONS CHECOTAH, OKLAHOMA AUGUST 4, 1985

INVESTIGATION

The Accident

About 12:30 a.m., c.d.t., on August 4, 1985, the drivers of two tractor-semitrailer vehicles departed the Explosives Transports, Inc., terminal in Oklahoma City, Oklahoma. They headed east on Interstate 40 (I-40) for their destination at Southport, North Carolina. One truck was transporting 20 MK 84 general purpose bombs and the other was transporting 10 MK 84 bombs. The 2,000-pound bombs had been loaded onto the flatbed semitrailers the previous day at the McAlester Army Ammunitions Plant in McAlester, Oklahoma, and had been transported to the carrier's terminal in Oklahoma City. The bombs were a part of a total shipment of 350 bombs previously loaded onto 13 Explosives Transports, Inc., vehicles on August 2 and 3, 1985, at the McAlester Army Ammunitions Plant.

The two trucks traveled east on I-40 for about 130 miles. About 3:30 a.m., as they approached Checotah, Oklahoma, both trucks were in the right lane with the truck carrying 10 bombs following the other.

The driver and passenger in a 1977 Ford LTD four-door sedan, also traveling east on I-40, had approached Checotah in the right lane shortly ahead of the trucks. The automobile driver had intended to exit I-40 at its intersection with U.S. 69 about 1 mile west of Checotah and then travel north to Peggs, Oklahoma. However, she passed the exit ramp for U.S. 69 and an exit ramp for Checotah ("old" U.S. 69) which was about a mile east of the U.S. 69 exit.

The driver slowed the automobile after realizing that she had passed her intended exit. She decided to proceed to the next ramp and then return to the exit she had missed. She saw a truck approaching her vehicle from behind and she expected the driver of the truck to pass her in the left lane; he did. However, she did not see the second truck until just before it struck the rear of the automobile which was in the right travel lane near the entrance ramp from "old" U.S. 69. The automobile then rotated clockwise about 180°, continued down the highway about 164 feet, and stopped parallel to and about 12 to 14 inches from the right guard rail, facing west (opposite its original direction of travel). The tractor-semitrailer continued to travel east and stopped near the front of the automobile. Both truckdrivers later stated that they saw the automobile move to the right shoulder and then reenter the right travel lane; however, the automobile driver stated that she did not leave the right travel lane.

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The lead truckdriver stated that he had attempted to alert the following truck driver about the slow moving automobile by using a citizens band radio installed in the truck. However, he said that immediately afterward he saw flames in his left outside rearview mirror. He continued to travel east on I-40 and called for help on his citizens band radio. The lead truckdriver said that he stopped at an exit a few miles east of the accident site and called his company dispatcher instead of the emergency telephone numbers listed on his shipping paper for the Department of Defense. (The carrier did not call McAlester Army Ammunition Plant until 5:05 a.m., about 1 1/2 hours after the accident.) The lead truckdriver then left his vehicle and returned to Checotah to determine the condition of the following truckdriver.

Immediately after the collision, a fire erupted and engulfed the rear and right side of the automobile and the front of the tractor. The truckdriver retrieved a fire extinguisher from the tractor and attempted to extinguish the fire on both vehicles; however, he was not able to extinguish the fire on either vehicle before the fire extinguisher was expended.

The automobile driver exited the vehicle through the driver's door. However, the passenger was injured and was not able to exit the automobile without assistance. The automobile passenger door was surrounded by fire and the driver's door could not be opened sufficiently to extricate the passenger because it was too close to the guardrail. Consequently, the automobile driver and the truckdriver pulled the passenger out of the automobile through the driver's door window, and then they helped her over the guardrail and down an adjacent hill toward "old" U.S. 69. The truckdriver told the automobile driver and passenger that he was transporting bombs and that there was a possibility of an explosion. The truckdriver then returned to the top of the hill to warn people approaching the vehicles to stay away from the truck and to watch for emergency response vehicles. The automobile driver told Safety Board investigators that as she and the passenger descended the hill, an explosion occurred and that she and the passenger were hit with hot flying glass. The truckdriver said that the first explosion involving bombs did not occur until later, after an ambulance had arrived onscene.

Fire, Explosions, and Emergency Response

At 3:34 a.m., an unidentified person called the Checotah Police Department and informed the police dispatcher of the accident on I-40. The police dispatcher sent a Checotah police officer to the accident site. The police officer said that when he approached the accident site, flames were high above the wreckage. He said that he assumed that a fuel tank truck was involved in the accident and reported that information to the police dispatcher. The police dispatcher subsequently notified the all-volunteer Checotah Fire Department and the Oklahoma Highway Patrol, and he requested a Checotah ambulance to respond to the scene.

Shortly afterward, the fire chief and firemen from the Checotah Fire Department approached the accident site on the entrance ramp from "old" U.S. 69. The fire chief said that he saw a low profile, flatbed semitrailer and that he immediately knew that a tank truck was not involved in the accident. The fire chief stated that as he drove closer to the accident site, he saw the back of the semitrailer and what he believed to be a Class A explosives placard. He directed a fireman to approach the vehicle on foot to verify the information on the placard. The fireman reported to the chief that the placard was for Class A explosives cargo. The fire chief then ordered all firemen to withdraw from their positions on I-40. At that time, three fire trucks were onscene. One fireman told Safety Board investigators that about this time the driver of the accident truck approached him

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at the entrance ramp to I-40 and told him that explosives were on the truck. The fireman said that the driver was unable to identify the type of explosives. The truckdriver told Safety Board investigators, however, that he recalled telling the fireman that there were bombs on the truck and that they had better "get some water" on the semitrailer. The fire chief said that during the incident he was not aware that the driver had spoken to one of the firemen.

About 3:45 a.m., the fire trucks were preparing to withdraw from the I-40 accident site when an explosion occurred. The fire chief said that he saw the mushroom effect of a bomb explosion and flying shrapnel and debris. He said that the explosion occurred near the front of the semitrailer and that, based on his military training, he was certain (after the incident) that a bomb had exploded. He described the explosion as "seeing a 104 or 105 Howitzer 1/ round go off, a bunch of Roman candles on the outside of it, and no flames." (See figure 1.)

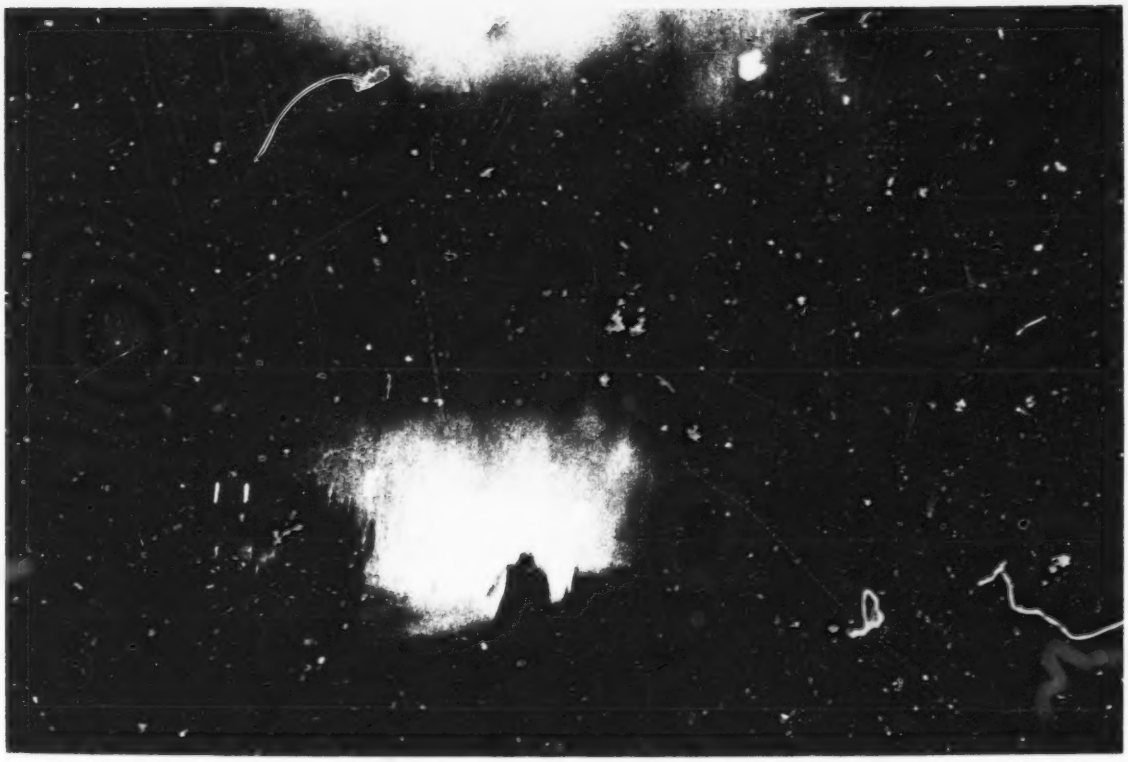

Figure 1..--Fire chief's truck in foreground of explosion.

1/ A short cannon.

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After the explosion, the truckdriver walked west on the eastbound lanes of I-40 to a McIntosh County Deputy Sheriff's car, and the fire trucks withdrew to safer locations. Shortly after 4 a.m., a second explosion occurred. The truckdriver and deputy sheriff moved farther west to the exit ramp for "old" U.S. 69 (about 1,100 feet from the accident site) where they met an Oklahoma Highway Patrol trooper. The truckdriver said that he told the State trooper that he was transporting bombs, and that when the State trooper asked for shipping papers he realized that he had left them in the truck. He provided the sheriff's deputy with the telephone number for Explosives Transport, Inc., and asked him to call them.

About 4:04 a.m., an ambulance, which was parked on "old" U.S. 69 under the overpass of I-40, departed the accident scene to transport the automobile driver and passenger to a hospital. A monitor nozzle on a fire truck that had been parked near the ambulance was used to spray water upward and west onto the burning wreckage. (See figure 2.) The fire chief then requested the Checotah dispatcher to call the Missouri-Kansas-Texas Railroad Company to request that traffic on a track adjacent to the accident site be stopped, and he ordered emergency response personnel to evacuate a nearby motel and gasoline station. City, county, and State troopers set up road blocks to control access to the accident site.

About 4:22 a.m., a third explosion occurred. Witnesses described the explosion, which shook Muskogee, Oklahoma, about 20 miles away, as the most violent. The explosion destroyed the accident tractor-semitrailer and automobile, and it made a crater 27 feet deep and 35 feet wide in the roadway. (See figure 3.) The concussion (overpressure) knocked several people who were near the accident site to the ground, including two firemen who were putting water on the burning wreckage from the fire truck parked on "old" U.S. 69. The firemen had been asked by the chief to put water on the burning wreckage until other emergency equipment was moved to safer locations. The fire chief was about to order the last two men to withdraw when the third explosion occurred.

The Checotah police dispatcher learned that the tractor-semitrailer was transporting bombs before the second explosion. At 3:55 a.m. (5 to 9 minutes before the second explosion), he told the highway patrol dispatcher that the truck was transporting ten 2,000-pound bombs. However, the fire chief told Safety Board investigators that he did not have access to highway patrol radio frequencies and that he did not learn that the truck was carrying bombs until after the third explosion. He said that it probably would not have affected his decisions because he considered all Class A explosives to be equally dangerous. Also, the fire chief said that, at the accident site, he used a copy of the U.S. Department of Transportation's (DOT) 1980 Emergency Response Guidebook for handling hazardous materials incidents. The guidebook does not differentiate between different types of Class A explosives. It states:

- an explosion may result if fire reaches the cargo area;
- fire may produce irritating or poisonous gases;
- stop all traffic and clear area for 2,500 feet (1/2 mile) in all directions; and
- try to prevent a fire from reaching the explosive cargo compartment but do not fight fire if it reaches the cargo.

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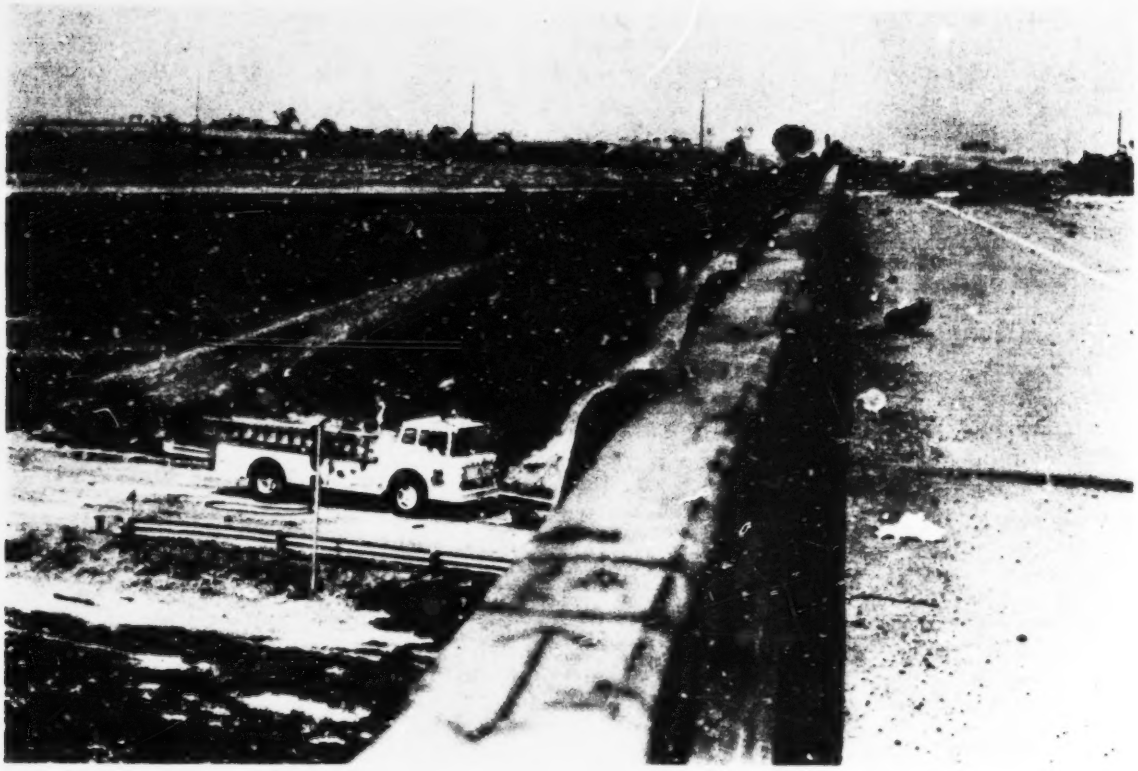

Figure 2.—Fire truck parked on "old" U.S. 69 about 150 feet east and 26 feet below the resting position of the semitrailer before the explosions. (Photograph courtesy of the State of Oklahoma Department of Transportation.)

About 4:30 a.m.. the Oklahoma Highway Patrol called the U.S. Army 61st Ordnance Detachment (61st), Explosives Ordnance Disposal (EOD), at Ft. Sill, Oklahoma, and informed them of the circumstances of the collision and explosions. Also, the highway patrol requested assistance from the 61st. The 61st commander advised the highway patrol that the detachment would respond to the scene and recommended that, in the meantime, the highway patrol take the following precautions:

- Shut off any oil field or natural gas pipelines within 300 to 500 yards of the accident site;
- Establish a 4-mile radius evacuation;
- Do not approach the incident site while signs of burning are still visible; and
- Do nothing for at least 2 hours after the fire has gone out.

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Figure 3.—Accident site.
(Photograph courtesy of the State of Oklahoma Department of Transportation.)

The precautionary information was forwarded to the Checotah Police Department a few minutes later.

Shortly afterward, the 61st commander called McAlester Army Ammunition Plant. He was told that the accident tractor-semitrailer was carrying 20 MK 84 LDGP 2,000-pound bombs filled with tritonal and that the bombs were not covered with thermal protective shields. The 61st commander later told Safety Board investigators that he had received from civilian and military personnel varying reports on the number of bombs involved in the accident—counts from 5 to 20 — and that only after arriving on scene did he ascertain that the vehicle had been transporting 10 bombs.

About 5:30 a.m., the highway patrol asked personnel at the 61st for information about the toxicity of smoke from burning explosive residue and about the need for decontaminating personnel at the site who came into contact with the residue. The 61st advised the highway patrol that smoke should be avoided and exposed skin should be washed with soap and water. (For additional information about tritonal, see Hazardous Materials Information, page 16.) A team from the 61st departed Ft. Sill at 7 a.m. onboard a Bell Helicopter model UH1 (Huey).

Meanwhile, the Checotah Civil Defense director established a command post at the city's fire station and requested help from a mutual aid response network. Fire departments from the cities of Eufala, Haskell, and Okmulgee, and Muskogee County

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responded with 45 firefighters. About 6 a.m., the Mayor of Checotah ordered an evacuation of the town's 5,000 people; the evacuation was completed by 7:45 a.m. At 6:52 a.m., officials of Checotah asked the Oklahoma Highway Patrol to contact the Governor's office and request that the Oklahoma National Guard respond.

The 61st team arrived at the accident site at 8:32 a.m. The 61st commander said that, based on his observation of thin, gray smoke and relatively small fires, he decided little danger of further detonation existed. He requested local emergency response personnel to extinguish grass and brush fires, and he advised local response personnel that evacuation distances could be reduced to a perimeter surrounding the accident site. Personnel from the 61st inspected the area and found one intact, 100 percent filled bomb adjacent to the accident site, one intact 80 to 90 percent burned out bomb about 150 to 175 feet south of the accident site, and one 3 1/2-foot-long rear section of a bomb (filled with explosive filler) approximately 150 to 175 feet soutwest of the crater. (See figure 4.)

The grass fires were extinguished by 9:30 a.m., and cleanup work on the I-40 westbound lanes was started. The Oklahoma National Guard provided about 150 personnel for cleanup and security assistance. Dump trucks, rough terrain forklifts, front end loaders,and flatbed trucks from McAlester Army Ammunition Plant were used to collect, consolidate, and transport explosive residue and the remaining intact bombs.

The westbound lanes of I-40 were reopened to traffic about 12:02 p.m., and residents were allowed to return to their homes about 12:30 p.m. At 5:30 p.m., personnel from the 52nd Ordnance Detachment of Pine Bluff Arsenal, Arkansas, arrived at the accident site to help transport the unexploded bombs and fragments containing explosive residue to Ft. Chaffee, Arkansas, for destruction.

Cleanup work at the site continued the next day. All remaining hazardous material was placed into plastic bags which were placed into 55-gallon drums. Transmission fluid was added to the drums of explosive residue to reduce friction, and the drums were transported to Ft. Sill. Contaminated water, soil, and metal were removed to McAlester Army Ammunition Plant. The 61st concluded its cleanup operations on August 7 and remained in the area until August 9 to provide explosive ordnance disposal support to the community.

Injuries to Persons

	Accident Truck	Automobile	Emergency Response Personnel	Other	Total
Fatal	0	0	0	0	0
Nonfatal	1	2	8	37	48
None	0	0	0	1	1
Total	1	2	8	38	49

Damage Information

Vehicles.—The tractor-semitrailer and automobile were destroyed by fire and explosions after the accident. (See figure 5.) Examination of the wreckage disclosed that the automobile had sustained moderate impact damage to the left rear section. The rear

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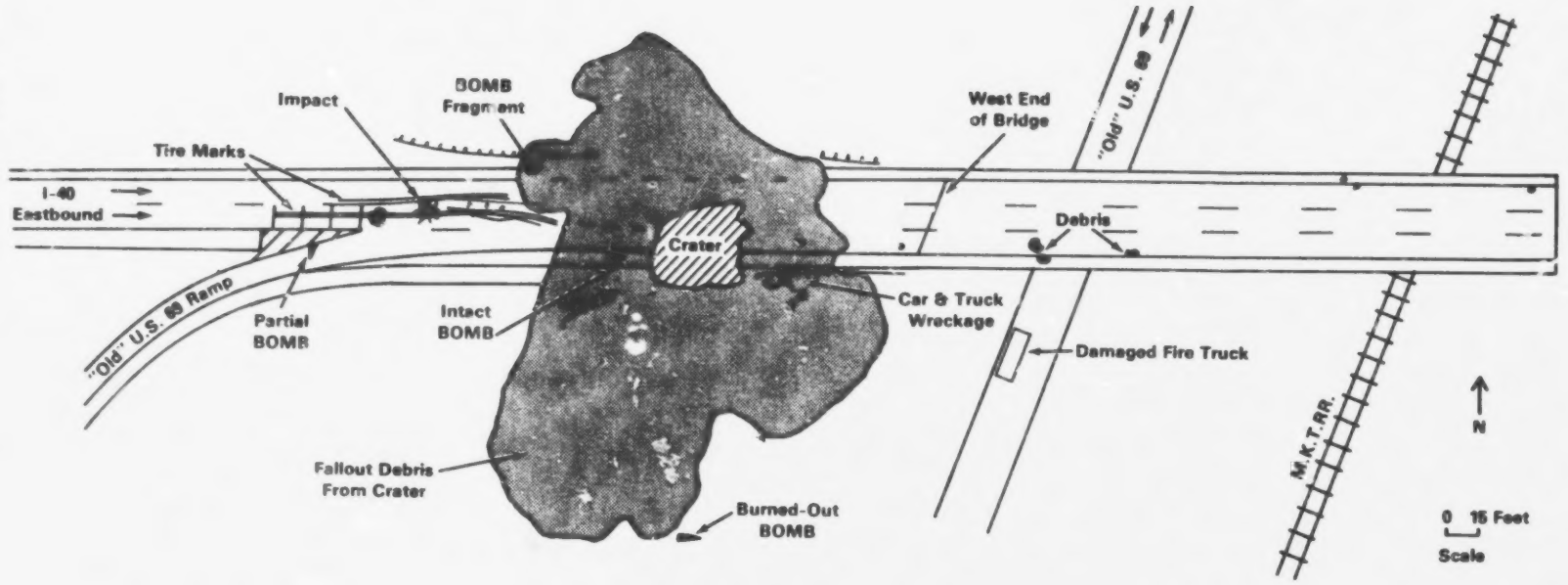

Figure 4.—Diagram of accident site.

Figure 5.—Tractor-semitrailer and automobile wreckage after explosions and fire.

bumper was pushed forward about 18 inches and downward into the 26-gallon capacity fuel tank. 2/ This penetration was about 56 inches to the left of the right edge of the bumper. A 5-inch split was found in the fuel tank adjacent to the area of maximum penetration by the rear bumper. (See figure 6.) The left frame rail was bent 23 inches downward from its point of attachment near the left rear shock absorber. It was crimped 32 inches forward of its attachment to the bumper.

Other.—The concussion (overpressure) and flying debris from the explosions caused substantial damage to many structures in the Checotah area. Buildings nearest to and north of the accident site generally sustained the most severe damage. (See figure 7.) The explosions shattered windows, damaged roof trusses and door frames, collapsed ceilings and light fixtures, and weakened interior and exterior walls. Total property damage was estimated at $5 million. 3/

The U.S. Army Corps of Engineers estimated that 371 residences within a radius of 6,200 feet of the accident site were damaged, 22 homes needed major reconstruction, and 11 homes needed to be rebuilt. Damage to residences was estimated at $2,200,000.

2/ The fuel tank was filled with gasoline about 45 miles before the accident site.
3/ Emergency response and other societal costs are not included.

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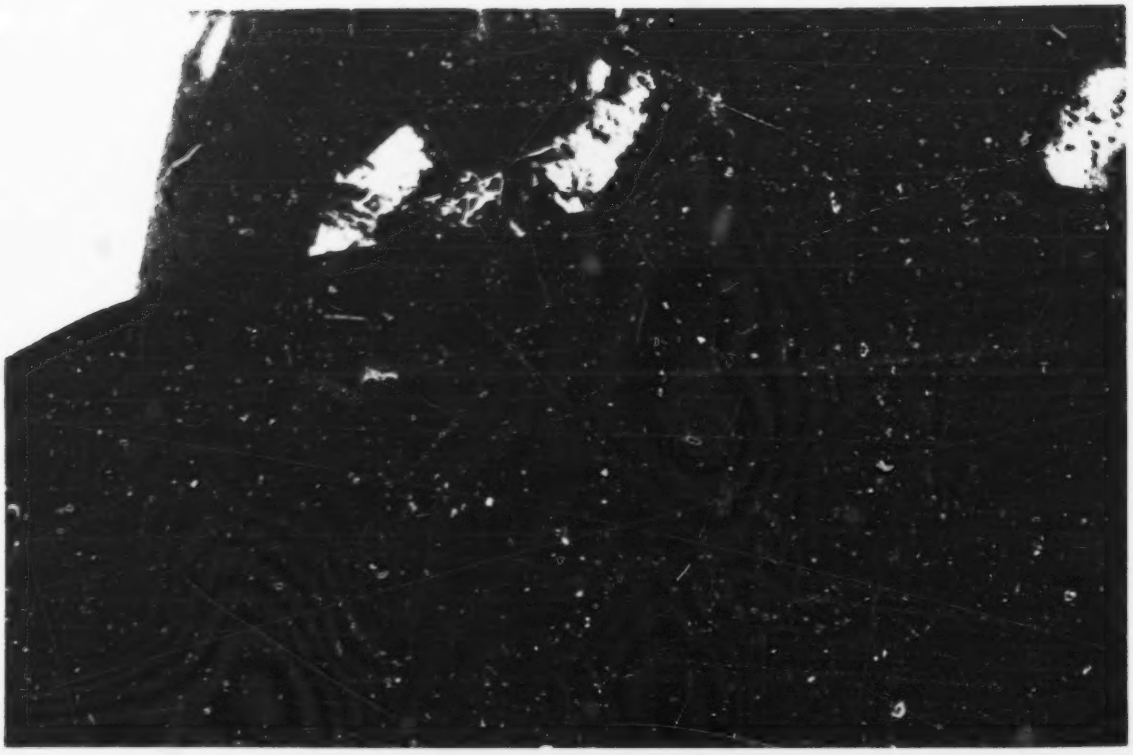

Figure 6.—Automobile fuel tank.

Several school buildings, a manufacturing plant, and two gasoline stations also incurred substantial damage. Damages to the Checotah Middle School, located about 734 feet north of the accident site were estimated at $215,000. Damage to other school buildings was estimated to be $85,000. (See figure 8.) Damage to commercial structures was estimated to be $225,000. About 60 percent of the plate glass windows in downtown Checotah (about 1 mile from the accident site) were shattered. (See figure 9.)

The explosions also destroyed a Checotah fire truck, two eastbound lanes of I-40, a merge lane from the "old" U.S. 69 entrance ramp, the right shoulder of the highway, several feet of guardrail, and numerous highway signs. (See figure 10.) Approximately 3,382 tons (1,700 cubic yards) of material were used to fill the crater left by the explosions. The Oklahoma Department of Transportation reported repair costs to be about $85,000.

Driver Information

Automobile Driver.—The 64-year-old automobile driver resided in Ashland, Wisconsin. She possessed a valid Wisconsin driver's license and a Wisconsin school bus operator's license. The driver reported that she had been driving since age 8, had 11 years of school bus driving experience, and had received formal Wisconsin school bus driver training. She previously had been convicted of one moving traffic violation, speeding (March 11, 1984).

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Figure 7.—Diagram of concentrated areas of structural and glass damage to buildings, Checotah, Oklahoma.

Figure 8.—Damage at Checotah school located near accident site.

Accident Truckdriver.—The 29-year-old truckdriver resided in Arnett, Oklahoma. He obtained an Oklahoma chauffeur's license at age 18, and was isssued a Texas chauffeur's license in 1982. He was convicted of four moving traffic violations (speeding) between March 1980 and September 1982, and his Oklahoma license was suspended in 1980 as a result of his failure to pay a fine. The truckdriver said that he was taught to drive tractor-semitrailers by other drivers and that he had not attended a formal driving school.

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Figure 9.—Checotah central business district located about 1 mile from the accident site.

At the time of the accident, the truckdriver had been employed by Explosives Transports, Inc., for about 2 months. He told Safety Board investigators that he had 5 years of truck driving experience; however, his available employment history records did not indicate any significant truck driving experience since September 1981. His Explosives Transports, Inc., employment application reported that between 1981 and 1985 he was employed as an equipment operator for two oil well testing companies. Representatives from one of the truckdriver's former employers told Safety Board investigators that the driver had driven a heavy equipment truck (not a combination vehicle) to and from job sites, and that his primary responsibilities had not been truck driving. The driver's employment application also showed that before 1981 he had driven a tractor-semitrailer for several months and that he had transported such commodities as cattle and rock.

On July 16 and 22, 1985, Explosives Transports, Inc., issued to the driver written warnings for exceeding hours of service limits established by the Federal Highway Administration (FHWA). He was cited by the carrier for exceeding 70 hours on duty time in 8 consecutive days in both instances and warned that "continued violations will result in your being disqualified to drive for Explosives Transport."

Lead Truckdriver.—The 30-year-old lead truckdriver resided in Choctaw, Oklahoma. He held an Oklahoma chauffeur's license. The truckdriver reported that he previously had been convicted of failure to stop for a red light and speeding. The driver

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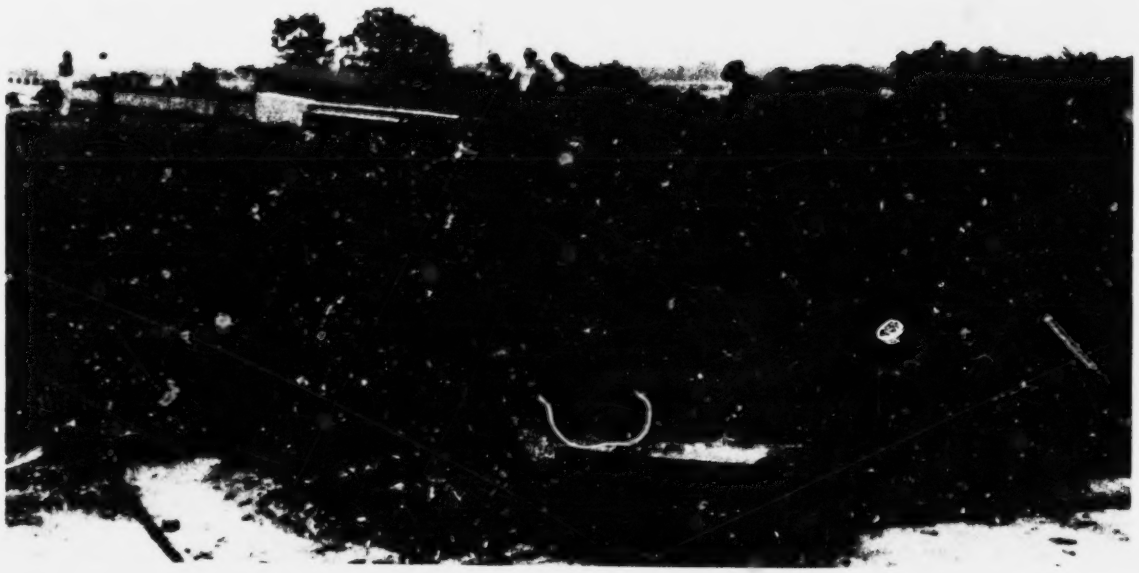

Figure 10.—Damaged I-40 eastbound lanes at accident site.

reported that he had learned to drive tractor-semitrailers through instruction provided by other truckdrivers and that he had not attended a formal truck driving school. At the time of the accident, he had been employed by Explosives Transports, Inc. for 9 months. He said that he had 3 years of full-time and 6 months of part-time truck driving experience.

Vehicle Information

Tractor-Semitrailer.—The combination vehicle consisted of a 1981 Freightliner Model FTL 8164T, three-axle, cab-over-engine tractor and a 1973 Fruehauf Model PB-F2-40, flatbed semitrailer. The equipment was owned and operated by Explosives Transports, Inc.

A driver of the truck the day before the accident told Safety Board investigators that he had encountered no mechanical problems with the truck. Also, an inspection of the tractor-semitrailer by an inspector of the McAlester Army Ammunition Plant on August 3 disclosed no safety or mechanical problems. The accident truckdriver said that during the pretrip inspection in Oklahoma City the brake lights on the trailer were not operating and that the dispatcher repaired the brake lights before he left.

At the time of the accident, 10 MK 84 general purpose bombs weighing 19,745 pounds were aboard the semitrailer. The gross weight of the tractor-semitrailer and cargo was about 43,400 pounds. The bombs were loaded in a single layer, two per pallet for a

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total of five pallets. The bombs were secured directly to the pallets; no shipping containers were used. The first two pallets were loaded side-by-side (four bombs across) at the front of the semitrailer; the noses of the bombs in this row faced the rear of the semitrailer. Two pallets were loaded immediately behind the first row; noses of the four bombs in the second row faced the front of the semitrailer and were separated from the first row of bombs by wooden planks. The fifth pallet was loaded onto the center of the semitrailer immediately behind the second row of bombs. The noses of the third row of bombs (two bombs) faced the front of the semitrailer and were separated from the second row by wooden planks. Wooden braces were nailed to the floor of the semitrailer and tiedown devices were used to secure the bombs and pallets to the semitrailer. The bombs were then covered with a fire-retardant tarpaulin. The driver reported that the bombs remained tightly secured to the semitrailer after the collision.

Automobile.—The 1977 Ford LTD 4-door sedan was equipped with a 351 cubic inch V-8 engine, power steering, power brakes, automatic transmission, and 3-point lap shoulder belts in the front seat. It weighed 4,140 pounds.

Highway Information

In the vicinity of the accident site, I-40 is typically an east-west, four-lane divided highway with two lanes in each direction separated by a 98-foot-wide depressed grass median. Each lane is 12 feet wide and is constructed of 9-inch-thick portland cement concrete. A 10-foot-wide asphalt shoulder is on the right side of the eastbound lane. The roadway is generally straight and flat near the accident site with a gentle curve and a slight grade. The posted speed limit is 55 mph. The road surface was dry at the time of the accident.

About 4,100 feet west of the accident site is the center of a full clover-leaf interchange with U.S. 69 which runs north-south. At the accident site, I-40 contains a partial clover-leaf (four legs with the two quadrants located on the west side of the interchange) at its junction with "old" U.S. 69 which runs north-south. A bridge, which is located immediately east of the accident site, passes over both "old" U.S. 69 and a Missouri-Kansas-Texas Railroad Company track.

Meteorological Information

At 3:55 a.m., on the day of the accident, the National Weather Service (NWS) station at Tulsa, Oklahoma, recorded broken cloud conditions at 8,000 feet and overcast cloud conditions at 25,000 feet, 7 miles surface visibility, 81° F temperature, dewpoint 73° F, and winds from the north/northeast at 12 mph. At 3:54 a.m., the NWS station at McAlester recorded clear skies, 6 miles surface visibility, 79° F temperature, dewpoint 74° F and winds from the south/southeast at about 5 mph.

Medical Information

Forty-nine persons reported to the Muskogee Regional Medical Center in Muskogee, Oklahoma. Most of these persons reported to the emergency room after breathing smoke and gases from burning tritonal (explosive filler). Many reported experiencing skin rashes, nausea, headaches, and breathing difficulties. Some persons reported to the medical center as a precaution even though they did not experience any injury symptoms. Those exposed to the tritonal were told to wash their skin with soap and water and to return to the center if they experienced any breathing difficulties.

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Neither the automobile driver nor the passenger used the available lap/shoulder belt restraint system. The automobile driver complained of pain in her right ribs; she was treated and released. The automobile passenger sustained a lacerated head, chest injury, and second degree burns on her back; she was admitted to the hospital.

The accident truckdriver reported that he wore a lap belt and that the lap belt "busted" during the accident. He complained of pain in the midportion of his lower back and the right side of his chest and bruises across his hips; he was treated and released. The lead truckdriver was treated for anxiety syndrome and released.

Two firemen, who were located about 150 feet from the wrecked vehicles at the time of the third explosion, were injured. One fireman sustained a perforated left eardrum and small superficial abrasions of the face; the other fireman sustained a sprained right thumb and postconcussive injury to his ears. Both firemen were treated and released.

Hazardous Materials Information

Descriptions.—Each MK 84 bomb weighed 1,970 pounds and contained 945 pounds of tritonal explosive filler. The bombs were shipped without tail assemblies, and neither boosters nor fuzes were installed in the bombs at the time they were transported. MK 84 bombs are about 98.8 inches long (without tail assemblies) and 18 inches in diameter. (See figure 11.) The bombs were manufactured at the McAlester Army Ammunition Plant for the U.S. Air Force.

General purpose bombs with tritonal filler have been used by the U.S. Air Force for over 25 years. Tritonal, a mixture of 80 percent TNT and 20 percent powdered aluminum, was developed and standardized in the United States during World War II. Aluminum is added to the TNT to increase the power of the explosion.

The Encyclopedia of Explosives and Related Items 4/ states:

> TNT (2,4,6-Trinitrotoluene) is considered moderately toxic overall, and highly toxic when inhaled, ingested or absorbed through the skin. 5/
>
> * * *
>
> The first signs of TNT intoxication are changes in blood: red blood cell count and hemoglobin content decrease; abnormal red cells are seen; and there is a transitory increase in leukocytes and lymphocytes. Rashes and skin eruption may be associated with these effects. Increased capillary fragility leads to nose bleeds and hemorrhages of the skin and mucosa. A second type of symptom, toxic jaundice, indicates toxic hepatitis which ultimately leads to yellow atrophy of the liver. Death can occur from either anemia or, especially in younger children, toxic hepatitis. The effects on the kidney are manifest in increased filtration in mild cases of TNT intoxication, urgency, frequent urination and lumbar pain may be the only symptoms. Individuals exposed to TNT may complain of a constant bitter taste, excessive salivation, nausea, vomiting and gastritis.

4/ Encyclopedia of Explosives and Related Items, Volume 9, U.S. Army Armament Research and Development Command, 1980.
5/ So long as TNT is encased in an intact bomb, it is not considered toxic; however, if the bomb should break or explode, it is considered toxic to human life.

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Figure 11.—MK 84 general purpose bomb at accident site.
(Photograph courtesy of the State of Oklahoma Department of Transportation.)

Before the accident, tritonal-filled MK 80-series bombs had been subjected to fast cook-off tests in a JP-5 fuel fire environment that simulated a large flight deck fire. Thefast cook-off tests consisted of subjecting the bombs to a continuous envelope of flame until destruction of the explosive load. Three MK 84 tritonal-filled bombs were

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tested and deflagrated 6/ at 4 minutes 57 seconds, 3 minutes 31 seconds, and 4 minutes 24 seconds.

Following explosions aboard the U.S.S. FORRESTAL in 1967 and the U.S.S. ENTERPRISE in 1969, the Department of Defense (DOD) identified a need to improve ship survivability at sea. It determined that one way was to change the way munitions acted in a fire.

In 1970, Cornell Aeronautical Laboratory, Inc., reported that the length of time bombs could withstand the heat from a jet-fuel fire before exploding could be almost tripled by painting them with an intumescent coating that swells and forms an insulating layer when heated. 7/ The report noted that the coating technique could be of great value to firefighters for fires aboard aircraft carriers and in ammunition supply depots because extra minutes might be sufficient to pull the bombs out of flames or for nearby personnel to seek safety.

In 1973, the DOD conducted fast cook-off tests on MK 84 bombs that were covered with an outside thermal protective coating. Subsequently, the Navy required that its bombs be manufactured with the outside thermal protective coating to increase the cook-off time from about 4 to about 9 minutes. While the U.S. Navy used a different explosive filler (H-6) in its MK 80 series bombs, the fast-cook off times for bombs filled with tritonal and H-6 were similar.

Outside thermal protective coating was not applied to the bombs involved in the Checctah accident; U.S. Air Force firefighting procedures do not require it. U.S. Air Force firefighting procedures recommend that its firefighting personnel withdraw to safe distances from fires involving munitions. However, according to the Commander, Naval Sea Systems Command, U.S. Navy bombs are coated with the thermal protection because of operational requirements to store the weapons onboard ships, and "fire fighting techniques required onboard ships are not the same as recommended for the land-based situation." Thermal protection is required on U.S. Navy bombs to allow a few extra minutes to extinguish onboard ship fires due to the potential for severe damage to the ship, and to evacuate ship personnel to safer locations.

Damage/Explosive Potential.—The principal threats to the safe transportation of MK 84 and other MK 80-series general purpose bombs are fire and heat; the bombs are relatively collision insensitive. Gasoline or diesel fuel contained in vehicle fuel tanks can, when released and ignited, provide sufficient heat to cause the bombs to deflagrate. Deflagrating bombs may then generate sufficient energy forces to detonate adjacent bombs, resulting in concussion and fragment hazards.

The Safety Board's investigations of accidents involving torpedoes in Denver, Colorado, on August 1, 1984, 8/ and bombs in Checotah on August 4, 1985, disclosed

6/ Deflagration is a violent reaction in which the output of heat is sufficient to enable the reaction to proceed and be accelerated without input of heat from another source. It is a surface phenomenon with the reaction products flowing away from the unreacted materials along the surface at subsonic velocity. The effect of a deflagration under confinement is an explosion. Confinement of the reaction increases pressure, rate of reaction, and temperature and may cause transition into a detonation.

7/ Research Trends, Cornell Aeronautical Laboratory, Inc., Buffalo, New York, Summer 1970.

8/ Hazardous Materials Accident Report—"Overturn of a Tractor-Semitrailer Transporting Torpedoes, Denver, Colorado, August 1, 1984" (NTSB/HZM-85/02).

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varied safety withdrawal distances recommended in munitions accidents. Recommended evacuation distances in Denver varied from 1,200 to 2,000 feet in case of fire; it was later estimated that fragments may have been propelled 4,500 feet had the torpedoes exploded. In Checotah, information accompanying the shipping papers recommended an evacuation distance of 2,500 feet in case of fire, and a subsequent evacuation distance of 4 miles was recommended by the 61st. The DOD had decided, after the Denver accident, to use a recommended evacuation distance of 2,500 feet on documents accompanying shipping papers because that distance was recommended in the U.S. Department of Transportation's Emergency Response Guidebook for Class A explosives.

Following the Checotah accident, the Defense Department Explosives Safety Board reviewed DOD policy guidance for safe separation distances to be used in conjunction with transportation accidents involving munitions and the layover of munition transporting vehicles at carrier terminals in populated areas. It calculated the minimum public withdrawal distances for accidents involving fire for a tractor-trailer loaded with bombs (and other heavy case munitions) to be 3/4 mile (4,000 feet) and for a rail car loaded with bombs to be 1 mile (5,280 feet). Blast overpressure at those distances was estimated to be about 0.3 psi for a fully loaded tractor-trailer and about 0.33 psi for a fully loaded rail car. The probability for a person in the open being hit by fragmenting munitions was estimated at less then 1×10^{-6} at or near a 4,000-foot range. The maximum net explosive weight for a fully loaded tractor-trailer was considered to be 50,000 pounds and for a fully loaded rail car to be 150,000 pounds. (The threshold required for glass breakage is about 0.25 psi, for ear damage 2.4 psi, and for lung damage 14.5 psi.)

On June 2, 1986, the DOD advised the Research and Special Programs Administration (RSPA) of the DOT that the Emergency Response Guidebook evacuation distance of 2,500 feet for some Class A explosives, including fragmenting explosive materials, is not adequate. It recommended that the evacuation distances for Class A explosives be extended to 4,000 feet (3/4 mile) for accidents involving tractor-trailers and 1 mile for accidents involving rail cars. The recommendation was based on the Defense Department Explosives Safety Board's assessment of hazards surrounding munition transportation accidents and the likelihood that emergency response personnel would not have adequate information available to immediately assess the real threats at a time when evacuations must be initiated. RSPA is reviewing the need for extending the current recommended evacuation distances.

The American Society for Testing and Materials (ASTM) recommends that emergency response personnel evacuate a distance of 5,000 feet when Class A explosives are involved in a fire. It notes that it would be prudent to evacuate the public further, to provide maneuvering room for emergency response personnel. 9/

Hazard Reduction Information. —Following chain reaction explosions in Roseville, California, on April 28, 1973, involving 18 railroad boxcars of high explosive bombs, and in Benson, Arizona, on May 24, 1973, involving 12 boxcars of bombs, the DOD initiated a study "to explore all options that could prevent future accidents." The study, entitled Safe Transportation of Munitions (STROM), was issued in June 1981. It states, in part:

- o Fire not impact is the principal threat to munitions;
- o Preventing fires or protecting the munitions from fire are the best ways to prevent the initial explosion;

9/ Guide to the Safe Handling of Hazardous Materials Accidents, ASTM STP 825, 1983.

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- o DOD's programs to protect munitions from fire focus on shipboard environment;
- o Coating the munitions with insulative materials or paints can help to delay the cook-off reaction. Efforts to prolong the cook off are intended to gain time for evacuation and not for firefighting;
- o Historically, the main reason for packaging munitions has been to provide protection from weather and from damage during handling and transport, but more importantly packaging can have a big affect on the ability of a munition to resist heat and fire;
- o It would be possible to build a safer munitions railcar, including the use of insulation and the application of intumescent coatings or paints, automatic fire sensors and alarms, and fire extinguishing systems;
- o DOD should further test fire-sensor-suppression systems for munitions railcars to determine their capability to perform during train operations and accident conditions, including derailments; chances for successful testing are good, about 80 percent;
- o The DOD should require that measures to prevent cook-off and mass detonation be a mandatory design consideration in requirements documents for all newly developed munitions (the instruction would have no impact on items already in inventory);
- o Transit time is the factor that most influences public exposure; and
- o In-transit exposure is not now considered, but is reducible by minimizing transit time.

In response to Safety Board investigators' inquiries, DOD officials said that fire-sensor-suppression systems and thermal insulation systems for railcars or highway vehicles were determined to be economically impractical because of the need for dedicated railcars or highway vehicles or the installation and removal of the system after each use.

DOD programs to protect munitions from fire also continue to focus on improving combat ship survivability. The U.S. Navy is testing the use of less sensitive energetic (explosive) materials in munitions. Thus far, current research efforts to improve the safety of the MK 80-series bombs have centered around the use of high explosive materials that are intended to react less violently when exposed to fire. Successful test results would allow the proposed discontinued use of outside thermal protective coatings which have presented special handling problems for the DOD.

The Naval Weapons Center, China Lake, California, conducted fast cook-off tests between June 11 and November 7, 1985, using five uncoated, improved bombs filled with plastic explosives. Desired, less violent reactions were experienced when three of the five bombs split open and burned instead of deflagrating. However, two of the uncoated, improved bombs deflagrated at about 4 minutes (5 minutes sooner than current coated bombs which deflagrate at about 9 minutes). Modified bomb cases are being considered to help assure that all bombs will split open and burn rather than deflagrate when exposed to fire, and the use of internal liners are being considered to extend the cook-off time.

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Carrier Information

General.—At the time of the accident, Explosives Transports, Inc., was located in Oklahoma City about 3/4 of a mile south of Interstate 240. The terminal facility was approximately 190 feet wide and approximately 600 feet long. Oil field related businesses were located about 300 to 400 feet away on the south side, and a mobile home park was located about 500 feet away on the opposite side.

The carrier owned four straight trucks, 30 tractors, and 55 trailers. It term-leased 5 tractors and trip-leased 10 trailers. The carrier employed 50 drivers and leased the services of another 5 drivers. Drivers were paid on a mileage basis; distances between origins and destinations were computed using the Household Goods Carriers Guide. The carrier reported two over-the-road accidents in the 12-month period before August 21, 1985. During the same period, the carrier reported that its vehicles were operated 786,938 miles.

Explosives Transports, Inc., operated as a common motor carrier of property under certificates of public convenience and necessity issued by the Interstate Commerce Commission. Records indicate that the carrier operated under a certificate issued as early as 1951 and that limited authority was granted to transport explosives between four States in 1956. In 1982, the carrier was granted authority to transport general commodities (excluding hazardous materials and munitions) between all points in the United States, excluding Alaska and Hawaii, for or on behalf of the United States Government. A year later, in 1983, the carrier was granted authority to transport hazardous materials and ordnance and accessories between all points in the United States except Alaska and Hawaii.

The president of Explosives Transports, Inc., told Safety Board investigators that after the Checotah accident the carrier "went out of business and sold the equipment to Coast Counties Express from Los Angeles, California." He said that Explosives Transports, Inc., still exists on paper and that it did not surrender its certificates from the Interstate Commerce Commission.

Safety Audits.--FHWA records indicate that it conducted three safety management audits on Explosives Transports, Inc., before the accident. A November 1967 safety audit disclosed that several drivers left vehicles transporting explosives unattended during off-duty periods on trips and that the carrier failed to make a timely report of an accident. In July 1972, a safety audit noted that 19 semitrailers loaded with Class A explosives were left unattended in the carrier's terminal area and that the vehicles were parked within 300 feet of buildings where people worked and congregated. The third audit, conducted in July 1973, noted that numerous drivers transporting Class A and Class B explosives failed to examine their vehicles every 2 hours or 100 miles.

About 1980, the FHWA initiated a program to assign safety ratings to motor carriers. Because Explosvies Transports, Inc., held operating authority from the Interstate Commerce Commission and no adverse Federal safety proceeding was pending against it, the FHWA assigned the carrier a satisfactory rating.

The next safety management audit was conducted on Explosives Transports, Inc., in August 1985, after the Checotah accident and 12 years after the last audit. The safety audit resulted in the assignment of an unsatisfactory safety rating and the preparation of an enforcement case by the safety investigator. The following safety violations were cited on the audit report:

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- Failing to maintain a driver qualification file on the driver operating the truck immediately ahead of the truck involved in the Checotah accident on August 4, 1985;

- Failing to maintain inquiries into the driver's driving record in driver qualification files, involving 3 of 10 drivers checked and including the driver involved in the Checotah accident on August 4, 1985;

- Failing to equip motor vehicles with brake linings adequate to provide for safe and reliable stopping on vehicles used to transport Class A explosives;

- Requiring or permitting drivers to make false entries on records of duty status involving 25 of 30 records checked;

- Failing to inspect and maintain vehicles to ensure safe and proper operating conditions involving 5 of 15 vehicles checked and including the tractor involved in the Checotah accident on August 4, 1985;

- Failing to keep minimum records of inspection and maintenance involving 80 of 80 vehicles [tractors, trucks, and semitrailers] checked and including the tractor and semitrailer involved in the Checotah accident on August 4, 1985;

- Failing to require motor vehicles containing Class A explosives to be attended involving 10 of 10 vehicles checked;

- Permitting persons to smoke a lighted cigarette within 25 feet of a motor vehicle containing hazardous materials (including Class B explosives); and

- Transporting and storing prohibited combination of hazardous materials together (Class A explosive detonating fuses, Class B explosive special fireworks, Class B rocket motor, and Class C explosive firing devices all in the same trailer).

Several violations of State safety requirements also were discovered during the Safety Board's investigation. For example, on June 15, 1985, an Explosives Transports, Inc., driver was cited by the California Highway Patrol for speeding while transporting bombs, Class A explosives. The officer noticed that a recapped tire on the vehicle was smoking and defective. He ordered road service for the vehicle and told the driver to not drive the vehicle with the defective tire on it. However, after the officer left, the driver continued his trip without correcting the tire problem. He was stopped by the California Highway Patrol about 15 miles later and cited for failure to obey a police order and driving a vehicle carrying Class A explosives with an unsafe tire. On September 11, 1984, the Missouri State Highway Patrol cited an Explosives Transports, Inc., driver for operating a vehicle with a "blown tire" while transporting cannon ammunition.

Truck Driver Training.--The accident truckdriver reported that when he first started to work for Explosives Transports, Inc., he received a 4 1/2-hour lecture from the carrier's safety officer. The lecture included basic emergency procedures, information on various State laws, safety inspections, safe havens and refuges, vehicle inspection

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procedures, inspection reports, and paperwork and documentation. The lead truckdriver reported that he received a 1-hour indoctrination briefing at the time he was hired by Explosives Transports, Inc. Except for indoctrination meetings with newly hired employees and the occasional posting of safety bulletins in the carrier's terminal, the Safety Board could find no evidence of other safety meetings or formal training provided by the carrier.

Drivers were provided with copies of a hazardous materials handbook, DOD safe haven/refuge locations, a California Highway Patrol route and safe stopping handbook, and other instructional material from the carrier. The lead truckdriver and the accident truckdriver were aware of company policies that required drivers to maintain a minimum following distance of 500 feet between trucks traveling together; that prohibited leaving vehicles loaded with Class A or Class B explosives unattended; and that required drivers to use seat belts.

DOD Motor Carrier Selection Information

The DOD's Military Traffic Management Command (MTMC), as the single manager for military traffic and land transportation, is responsible for the procurement of freight transportation services from commercial for-hire transportation companies. MTMC uses approximately 3,000 motor carriers for the movement of general freight and 40 carriers for the transportation of explosives. It provides service to about 1,500 military installations (shippers and receivers) and activities. The total number of DOD explosive shipments has increased in recent years from 23,456 shipments in fiscal year 1980 to 47,593 in fiscal year 1986 (42,364 by highway). During the same 7-year period, the MTMC reported a total of 49 highway accidents involving DOD Class A and Class B explosives shipments in 25 States. 10/

Before using a motor carrier to transport Class A or Class B explosives, the MTMC requires the motor carrier to provide satisfactory service to MTMC as a general freight carrier for at least 1 year and to have a "satisfactory safety rating" from the Bureau of Motor Carrier Safety (BMCS). 11/ Emphasis in the selection of common carriers is placed on service, economy, and safety.

At the time of the accident, MTMC had established a carrier performance program which set minimum levels of satisfactory service performance for carriers and incorporated procedures for denial of DOD freight shipments to those carriers that failed to maintain the minimum level of satisfactory performance. The MTMC is responsible for the overall management of the program, for monitoring effectiveness of the program, and for reviewing disqualification actions imposed on carriers that exclude a carrier from transporting DOD freight at one or more points.

Commanders at shipping facilities are delegated limited authority to disqualify a carrier. When a carrier's equipment arrives at a shipper's facility, it is inspected and, if found to be in unsatisfactory condition, it is rejected. If a carrier's equipment is rejected three times in 30 days, the carrier is subject to the denial of additional shipments from that facility. Transportation officers at shipping facilities have the authority to discontinue using a carrier for up to 60 days for shipment refusals, inadequate/improper equipment, and failure to pickup freight as agreed.

10/ The 49 accidents include truckload and less-than-truckload shipments, accidents caused by the truckdrivers, and accidents caused by the drivers of other vehicles involved in the accidents.

11/ The FHWA recently reorganized functions performed by the BMCS and assigned those functions to newly formed offices within the FHWA.

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The MTMC requires motor carriers to sign an agreement to meet several conditions before transporting any Class A or Class B explosive materials. Some of these conditions include:

- Compliance with all Department of Transportation safety regulations;
- Maintenance of a "satisfactory safety rating" with the Bureau of Motor Carrier Safety;
- Conduct of safety/security surveys of its facilities and equipment;
- Evidence of an active safety and security training and evaluation program for its drivers;
- Inspection of carrier equipment at pickup and delivery facilities;
- No use of drivers with records of disqualifying offense as specified in 49 CFR 391.15 to operate any vehicle transporting Class A or Class B explosives;
- Use of drivers with a minimum of at least 1 year of general commodities driving experience (using similar equipment) before transporting an explosives shipment;
- Use of drivers that are trained and competent in the movement of explosives and who understand pertinent instructions and procedures;
- Requirement that the drivers of vehicles transporting Class A and Class B explosives undergo annual physical examinations. (DOT regulations require a physical examination once every 2 years.)

On March 4, 1985, the MTMC disqualified Explosives Transports, Inc., for 60 days from transporting Class A and Class B ammunition and explosive shipments originating at its shipping facilities in 20 western States because of unsatisfacory service; the disqualification was effective February 7, 1985. DOD reports showed that the carrier improperly applied Class B explosive placards to a vehicle transporting Class A explosives; left a load of Class A explosives unattended in an unsecured area; failed to properly secure grenades that were found scattered across the floor of a trailer; failed to notify appropriate personnel about a delayed shipment; and delivered less explosives to a destination than consigned at origin (the explosives were later found at the carrier's terminal and delivered to the destination).

However, despite the MTMC disqualification actions, six shipping facilities in the affected States used Explosives Transports, Inc., to transport 15 Class A and Class B explosive shipments during the suspension period. MTMC personnel told Safety Board investigators that six shipments moved during the suspension period because of delays in distributing the suspension information to its shippers; that two shippers apparently failed to remove the carrier from its list which resulted in the movement of eight loads by the carrier; and that one shipment was arranged by MTMC's Eastern Area headquarters which was not subject to the jurisdiction of the Western Area headquarters that had issued the suspension order.

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At the time of the accident, MTMC did not conduct safety audits or surveys of motor carriers. However, the Army Vice Chief of Staff approved in September 1985, a program to use Transportation Safety and Security (TRANSS) teams to check carrier safety and security performance. The first team began operating in April 1986, and MTMC proposes additional teams to screen carrier applicants.

Routing and Transit Time Information

Carrier.—All Explosives Tranports, Inc., drivers were dispatched by the company's central dispatch operations in Oklahoma City. The drivers generally were dispatched on a first-in first-out basis and given a choice of trips available. There was no company policy that required trucks moving in the same direction to travel together; however, according to drivers interviewed, trucks going in the same direction were often dispatched together. The drivers said that they often traveled together for companionship, for assistance in case of breakdowns, and for security.

According to Explosives Transports, Inc., officials (a vice-president, the operations manager, and the safety director), drivers transporting Class A and Class B explosives were furnished a list of safe havens 12/ but were not instructed to follow specific routes. Instead, drivers were responsible for planning the routes that they would travel.

Explosives Transports, Inc., drivers regularly dropped off empty trailers at the McAlester Army Ammunition Plant and picked up loaded trailers of explosives for return to the carrier's terminal in Oklahoma City. Loaded trailers would then sit at the carrier's terminal until drivers were available to take them on to the destinations. Less-than-full truckload shipments would be consolidated at the terminal.

Safety Board investigators examined documents for hundreds of Class A and Class B explosive shipments transported by Explosives Transports, Inc., for the DOD. For most of those shipments, the DOD required the carrier to provide "constant surveillance service" or "protective service" which required the carrier to maintain a chain-of-custody record (DD Form 1907— Signature and Tally Record). The form identifies the shipment, origin, destination, date and location tendered to the carrier, date and location of delivery, persons accepting custody, and dates and locations where a change in custody is performed. At the end of the trip, the completed Signature and Tally Record is given to the consignee.

An examination of the available Signature and Tally Records for Class A and Class B explosive shipments transported by Explosive Transports, Inc., disclosed that many shipments were transported through the carrier's Oklahoma City terminal, regardless of whether Oklahoma City was on the most direct route from origin to destination.

The examination revealed that the following shipments, as well as other truckload and less-than-truckload shipments of explosives, were regularly transported unnecessary miles, thereby increasing public exposure to the risks of transporting explosives:

- On July 25, 1985, 115 pounds of Class A explosives was picked up at Carson City, Nevada, and transported to Oklahoma City, where it remained for several days. It was then transported to Fort

12/ A safe haven is an area specifically approved in writing by local, State, or Federal government authority for the parking of unattended vehicles containing Class A and B explosives (49 CFR 397.5). Usually these locations are truck stops.

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Carson, Colorado, where it was delivered on August 6, 1985, 12 days later. While the direct mileage from origin to destination is about 1,043 highway miles, the distance through Oklahoma City is about 2,128 miles, an increase of about 1,085 highway miles.

- On February 7, 1985, a shipment of 300 pounds of Class A explosives was picked up at Yuma, Arizona, and transported to Oklahoma City. The shipment was delivered to its destination, China Lake, California, 8 days later. The distance between Yuma and China Lake is about 290 miles. The highway mileage from origin to destination through Oklahoma City is about 2,396 miles, an increase of 2,106 miles.

The shipment of bombs involved in the Checotah accident also was transported over an indirect route. After the bombs were loaded onto the semitrailer at McAlester, the carrier transported the shipment about 121 miles west to the Oklahoma City terminal. The bombs were then transported about 130 miles east toward their destination. When the accident occurred in Checotah, the bombs had been transported about 250 miles by the carrier. The distance from the shipper's facility to the Checotah accident site is about 50 miles.

While there may be economic incentive to transport less-than-truckload shipments to a central point for consolidation when reasonable circumstances permit, the economic burden of transporting less-than-truckload shipments of explosives was lessened by the use of a minimum weight charge. Shipping papers show that the carrier was generally paid for a minimum weight of 2,500 pounds even when the weights of shipments were substantially less. For example, the transportation charge for a shipment of 16 pounds (computed as 2,500 pounds) of Class A explosives from Hawthorne, Nevada, to Coronado, California, on July 23, 1985, was $516.

Examination of the Signature and Tally Records also disclosed that both truckload and less-than-truckload explosive shipments transported to Oklahoma City regularly sat at the carrier's terminal for several days before moving on to the destinations. The following examples illustrate how the carrier's operating procedures both increased transit time for explosives shipments and increased threats to persons who lived or worked near the carrier's terminal:

- A shipment of 40,810 pounds of Class B explosives was shipped from Newport Beach, California, on May 22, 1985, for delivery to Yorktown, Virginia. It arrived in Oklahoma City on May 23 where it remained until May 28 (6 days). It was finally delivered May 31, 1985.

- A shipment of 40,290 pounds of Class B explosives was shipped from Nimbus, California, on February 11, 1985, for delivery to Charleston, South Carolina. It arrived in Oklahoma City on February 13 where it remained until February 23 (11 days). It was finally delivered on February 25, 1985.

- A shipment of 43,780 pounds of Class A explosives was shipped from Concord, California, on May 10, 1985, for delivery to Yorktown, Virgina. It arrived in Oklahoma City on May 12 where it remained until May 18 (7 days). It was finally delivered on May 21, 1985.

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- A shipment of 40,135 pounds of Class A explosives was shipped from McAlester Army Ammunition Plant on July 17, 1985, for delivery to Tooele Army Depot, Utah. It arrived in Oklahoma City on July 17, but it was not delivered to the destination until July 30, 1985, 13 days later.

The DOD has computed standard transit times for both truckload and less-than-truckload shipments. Computation of transit time starts when a shipment is picked up and stops when the shipment is offered for delivery. However, Safety Board investigators found that Explosives Transports, Inc., regularly exceeded the standard transit times. For example, the DOD standard transit time guide for a truckload shipment of explosives from Oklahoma to Utah is 2 days, but the carrier took 13 days.

After the Checotah accident and after the FHWA assignment of an unsatisfactory safety rating, the DOD discontinued using Explosives Transports, Inc., to transport Class A or Class B explosives shipments. Representatives of the DOD entered the Explosives Transports, Inc., terminal and found eight full truckload shipments and seven dromedary shipments of Class A and B explosives. The shipments were transferred to the equipment of other motor carriers for delivery to their destinations.

U.S. Department of Defense.—The DOD does not designate or approve highway routes used by motor carriers to transport its Class A or B explosives. It believes that the DOT delegated responsibility to the carrier to determine which highway routes should be used.

On May 8, 1986, the Defense Department Explosives Safety Board responded to a request from the Office of the Assistant Secretary, Department of the Army for guidance with respect to safe separation distances to be used in conjunction with "the layover of munitions transporting vehicles at carrier terminals in populated areas." However, it decided against the promulgation of separation distance standards following an MTMC recommendation that carriers transporting explosives instead be required to comply with applicable National Fire Protection Association (NFPA) standards for carrier terminals and be verified by MTMC security/safety survey teams.

NFPA Standard for Explosives Motor Vehicle Terminals, 498-1982, is "intended to provide reasonable requirements for the prevention of fires within and the spread of fire into explosives at motor vehicle terminals." It notes that terminals provide vehicle maintenance and driver rest services, but it does not recommend the maximum amount of time truckload shipments of explosives should be allowed to remain at the terminal. NFPA states that less-than-truckload shipments of explosives:

> . . . shall not be retained on the lot, either in a trailer or temporary storage facility, for a period longer than necessary, but in no case for more than 72 hours, unless the explosives are stored in a temporary storage facility located away from inhabited buildings, passenger railways, and public highways and from other temporary storage facilities so as to comply with the American Table of Distances for Storage of Explosives.

The American Table of Distances for Storage of Explosives recommends that explosive shipments weighing between 40,000 and 45,000 pounds be stored 2,000 feet from unbarricaded inhabited buildings; 800 feet from unbarricaded public highways, and 2,000 feet from public highways with a traffic volume of 3,000 vehicles/day.

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U.S. Department of Transportation.--DOT regulations do not designate specific routes which motor vehicles must follow when transporting explosives. However, 49 CFR 397 requires carriers to consider safety factors, such as population density, route characteristics, special populations, and emergency response capabilities, when selecting routes. Additionally, 49 CFR 397 permits vehicles loaded with Class A or Class B explosives to be parked at a carrier's terminal when properly attended, but no closer than 300 feet from dwellings, buildings, or places where people work, congregate, or assemble. Title 49 CFR 177.853 requires all shipments of hazardous materials to be "transported without unnecessary delay, from and including the time of commencement of the loading of the cargo until its final discharge at destination."

ANALYSIS

The Accident and Explosions

The general purpose bombs exploded after exposure to heat from a fire which occurred when the second of two tractor-semitrailers loaded with bombs collided with the automobile. The front of the tractor-semitrailer penetrated 18 inches into the rear of the automobile and caused a 5-inch split in the nearly full automobile gasoline fuel tank. The spilled gasoline quickly ignited and engulfed the automobile and the tractor in flames. The first of three explosions involving the bombs occurred about 15 minutes after the collision and was probably a deflagration with propulsion. The second explosion occurred about 30 minutes after the collision and also was probably a deflagration with propulsion. The third and most violent explosion occurred about 52 minutes after the collision and probably involved partial to full detonations of several bombs.

DOD Transportation Safety Oversight

Public exposure to munitions shipments has doubled in the past 7 years, increasing from 23,456 shipments in 1980 to 47,593 in 1986. During the same period, DOD Class A and Class B explosives shipments have been involved in 49 highway accidents in 25 States. Following the investigation of the accident involving the overturn of a tractor-semitrailer transporting torpedoes in Denver, Colorado, the Safety Board concluded that the DOD's munitions transportation safety program was inadequate. The Safety Board found that the DOD did not conduct its own safety audits or surveys of motor carriers. The Safety Board concluded that the DOD relied upon essentially illusory programs to ensure the safety of its shipments; it relied on the FHWA motor carrier safety ratings.

Safety Audits.—During the investigation of the Checotah accident, the Safety Board found that again, the DOD essentially had relied upon the FHWA motor carrier safety ratings to determine the carrier's safety fitness. Although Explosives Transports, Inc., had been assigned a satisfactory safety rating by the FHWA at the time of the accident, the FHWA had not performed a safety audit on the carrier since 1973, 12 years before the accident. An FHWA safety audit conducted on the carrier within 3 weeks of the Checotah accident resulted in an unsatisfactory safety rating and the preparation of an enforcement case for multiple safety violations, including inadequate driver qualification files, false entries on drivers' records of duty, inadequate records of vehicle maintenance, failure to require motor vehicles containing Class A explosives to be attended, and transportation and storage of a prohibited combination of hazardous materials.

As a result of its investigation of the August 1, 1984, accident in Denver, the Safety Board recommended that the DOD:

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I-85-25

Establish Department of Defense safety requirements for the safe transportation of explosive and other high-hazard Department of Defense shipments which motor carriers must meet, in addition to U.S. Department of Transportation requirements.

I-85-26

Establish a safety evaluation program to monitor motor carrier compliance with Department of Defense safety requirements for explosive and other high-hazard Department of Defense shipments.

On July 21, 1986, the DOD advised the Safety Board that it had initiated action to develop and implement a program to evaluate and monitor carriers which transport DOD explosives and sensitive shipments. It said that the program was scheduled to be funded in fiscal year (FY) 1988 and that it would involve actual visits to carrier terminals and home offices. DOD also said that roadside inspections would be performed, that audits would be conducted similar to those of the FHWA to ensure compliance with FHWA and DOD regulations, and that serious shortfalls in carrier safety compliance would be a basis for immediate non-use of the carrier. The DOD advised that specific DOD training requirements as well as training aids, are being developed, to help drivers better understand the characteristics of the explosives they transport and their responsibilities in the event of an emergency situation. In addition, the Safety and Security Committee of the Munitions Carriers Conference has been working with the MTMC to establish safety training standards for drivers who transport Class A and Class B explosives. As a result of the DOD's response, the Safety Board placed Safety Recommendations I-85-25 and -26 in an "Open--Acceptable Action" status. The Checotah accident points out the need for the DOD to move expeditiously.

If the DOD had conducted a safety audit on Explosives Transports, Inc., before the Checotah accident, it should have been able to identify the same safety deficiencies that were identified by the FHWA in a postaccident audit. In addition, the DOD should have been able to determine that the carrier did not meet safety requirements contained in an agreement with the DOD, such as evidence of an active safety and security training and evaluation program for its drivers; the use of drivers with a minimum of at least 1 year of general commodities driving experience (using similar equipment) before transporting explosives shipments; and the use of drivers who are trained and competent in the movement of explosives and who understand pertinent instructions and procedures.

Truck Driver Training and Experience.—Although the accident truckdriver was properly licensed to drive the combination vehicle at the time of the accident, he had not attended any formal driver training program and except for the 2 months he had been employed by Explosives Transports, Inc., he had accumulated no significant tractor-semitrailer driving experience in the previous 4 years. While the DOD agreement with munitions carriers requires that drivers have a minimum of at least 1 year of general commodities driving experience before transporting explosives shipments, there is no requirement that it be recent driving experience or that it be without serious traffic violations.

Further, the Safety Board could find no evidence of an adequate safety training and evaluation program for the drivers. Explosives Transports, Inc., provided extremely

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limited indoctrination training to its new drivers in the form of a brief lecture from the safety officer that addressed basic operational information and emergency procedures. No other safety meetings or instruction was provided to the drivers.

Previous Safety Board accident investigations have identified experience and training as causal factors. Following the investigation of an accident involving 18 surface-to-air missiles near Los Banos, California, on December 2, 1982, and numerous other accidents 13/ involving trucks transporting hazardous materials where driver error or deficiency was found to be a causal factor, the Safety Board concluded:

> . . . if employee's driver license records and levels of operational experience were reviewed more carefully and more stringent standards were established for licensing and employment, the number of truck accidents involving hazardous materials resulting from errors by drivers could be decreased.

In its investigation of the Denver accident involving torpedoes, the Safety Board found that driver inexperience was the major factor, and the accident report noted several comments to an FHWA advanced notice of proposed rulemaking that included driver qualification requirements. Respondent's to the proposed rulemaking commented on a need to require truckdrivers to meet more stringent qualification criteria before allowing them to transport hazardous materials. For example, the Minnesota State Patrol recommended that all operators of vehicles transporting hazardous materials should have at least 2 to 3 years of verifiable experience operating similar vehicles under all weather conditions. The Engineering and Safety Service of the American Insurance Service Group, Inc., which represents a large segment of the property and casualty insurance industry, recommended that drivers transporting certain hazardous materials have 5 years of experience operating other equipment, have not more than three moving violations in the past 3 years, and have not more than one DOT-reportable accident in the past 2 years.

In a special study of railroad/highway grade crossing accidents involving trucks transporting hazardous materials, 14/ the Safety Board found that some carriers are selective in hiring drivers for hazardous materials trucks. One carrier identified in the report will not consider for employment any driver without at least 2 years of accident-free driving on semitrailer units.

In its safety study on training, licensing, and qualification standards for drivers of heavy trucks, 15/ the Safety Board said that "drivers transporting hazardous materials need specialized knowledge. They must know the properties of their cargo and the rules of the road concerning transportation of those materials. In the event of a mishap, they will be among the first persons at the scene, so they must be familiar with emergency response procedures." The Safety Board also said that a driver should "have to demonstrate proficiency in handling hazardous materials trucks, as well as mastery of the knowledge related to hazardous materials transport."

13/ Safety Recommendation Letter H-83-31 through -33 and -38 to the American Association of Motor Vehicle Administrators, July 8, 1983.
14/ Special Study—"Railroad/Highway Grade Crossing Accidents Involving Trucks Transporting Bulk Hazardous Materials" (NTSB-HZM-81-2).
15/ Safety Study—"Training, Licensing, and Qualification Standards for Drivers of Heavy Trucks" (NTSB/SS-86/02).

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On October 27, 1986, the Commercial Motor Vehicle Safety Act of 1986 (PL 99-570) was signed into law. It requires the Secretary of Transportation to establish minimum Federal standards for testing and ensuring the fitness of individuals who operate commercial vehicles. The Act further states that when hazardous materials are transported, such drivers must have a working knowledge of handling the material, the operation of emergency equipment used in response to emergencies arising out of the transportation of the material, and appropriate response procedures to be followed in emergencies. The Safety Board urges the Secretary of Transportation to move expeditiously to develop stringent experienced, driver history, and training requirements.

Hazardous Materials Routing.—Title 49 CFR 177.853 requires all shipments of hazardous materials to be "transported without unnecessary delay, from and including the time of commencement of the loading of the cargo until its final discharge at destination." However, the regulation does not define unnecessary delay nor specifically prohibit carriers from transporting explosives shipments over indirect routes that may increase highway mileage but provide no increased safety benefits, such as travel through less populated areas or over lower accident risk highways. In its investigation of the Denver accident, the Safety Board concluded that the Federal Motor Carrier Safety Regulations describe motor carrier routing requirements in ambiguous terms. Also, it was unclear whether the carrier involved in that accident violated any Federal regulations by routing the vehicle through an interchange near downtown Denver instead of over a bypass that would have directed the vehicle away from the central business district. As a result, the Safety Board recommended that the BMCS of the FHWA:

H-85-34

Amend Federal Motor Carrier Safety Regulation 49 CFR 397.9 to eliminate ambiguities in the routing requirements for vehicles transporting hazardous materials.

On November 26, 1986, the FHWA advised the Safety Board that because Section 206 of the Motor Carrier Safety Act of 1984 prohibits the modification or elimination of any regulation relative to the transportation of hazardous materials unless and until an equivalent or more stringent regulation has been promulgated under the Hazardous Materials Act, the Secretary of Transportation delegated the responsibility for the development and promulgation of the regulations to the Research and Special Programs Administration (RSPA). No further action has been taken on the recommendation which remains in an "Open--Acceptable Action" status. Because of the severe consequences that can result when accidents involving explosives are involved in accidents, the Safety Board urges the FHWA and the RSPA to move expeditiously on this recommendation.

In its Denver report, the Safety Board also said that "the safest through routing for the transportation of hazardous materials can best be developed at the State level of government where concerns and problems of local jurisdictions can be coordinated to ensure that the routes selected minimize the population at risk and that due regard is taken relative to the level of preparedness of local jurisdictions to handle emergency situations." On November 15, 1985, the Safety Board recommended that the FHWA:

H-85-38

Encourage States to establish through routes for shipments of hazardous materials, and coordinate the compatibility of the designated routes regionally and nationally.

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On October 8, 1986, the FHWA advised the Safety Board that it also had forwarded the recommendation to the RSPA because of the responsibilities recently delegated to that Administration by the Secretary of Transportation. There has been no further response to the recommendation, which remains in an "Open" status. Therefore, the Safety Board urges the FHWA and RSPA to also move expeditiously on Safety Recommendation H-85-38.

Also, as a result of the Denver accident investigation, the Safety Board concluded that the DOD should evaluate highway routes selected by motor carriers to transport explosive shipments to ensure that motor carriers use the most direct routes consistent with public safety. The DOD also had previously recognized a need to minimize transit time. The STROM report concluded that transit time is the factor that most influences public exposure (to the risks of munitions transportation) and that in-transit exposure is not now considered, but is reducible by minimizing transit time.

In the Checotah accident, however, the Safety Board found that Class A and Class B explosives shipments transported by Explosives Transports, Inc., for the DOD regularly experienced unnecessarily long transit times. Not only were munitions often transported over indirect routes for hundreds of unnecessary miles, but shipments regularly were held at carrier terminals for several days while in-transit. The accumulation of multiple in-transit shipments of Class A and Class B explosives at the carrier's terminal in Oklahoma City also unnecessarily exposed the public in that area to significantly increased risks.

The DOD currently requires that carriers maintain a record of chain-of-custody (DD Form 1907—Signature and Talley Record) for most munitions shipments that track the movement of a shipment from origin to destination. The DOD should use the information available on these completed documents, in conjunction with other carrier records, to verify the accuracy of the information, to identify shipments that are not moving expeditiously between points of origin and destination, and to take effective action to correct problems identified.

While the Safety Board found that the DOD had identified some safety problems with Explosives Transports, Inc., in early 1985 and ordered its shipping facilities in the Western Area to not use the carrier for a 60-day suspension period, the Safety Board found that several shipments of Class A and Class B explosives shipments were tendered to the carrier during the non-use period, thus reducing the effectiveness of the suspension action. However, following the accident in Checotah, the DOD revised its suspension procedures to disqualify munitions carriers nationwide instead of within area commands when safety problems are identified. In addition, the DOD has changed its procedures to provide more timely notifications to shipping facilities when motor carriers are no longer authorized to transport its explosives shipments.

As the shipper of many unique, highly dangerous explosives developed to meet its specific needs, the DOD is best capable of determining the hazards to public safety posed by the transportation of its shipments. Consequently, the DOD should use this information for controlling routing of truckload and less-than-truckload shipments to minimize the time and extent of public exposure. Clearly, the DOD should establish a process for controlling the routing of its shipments not just for highway, but for rail and other transportation systems.

For its highway transportation of explosives, the DOD should expect assistance from the FHWA, the RSPA, and the States for establishing an acceptable nationwide system for the routing of hazardous materials. Until this nationwide system is established, the DOD

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must provide overall routing direction for the carriers it uses. However, even the establishment of a nationwide system will not relieve the DOD of its routing responsibilities. It still will be necessary for the DOD to exercise control over the selection of specific routes from among those approved by the States for the transportation of shipments that present unique or widespread threats to public safety.

Munitions Hazards

The principal threats to the safe transportation of general purpose bombs and other Class A and Class B explosive munitions are fire and heat. During fast cook-off tests conducted on general purpose bombs similar to those involved in the Checotah accident, the bombs deflagrated in about 4 minutes. Fast cook-off tests conducted on other munitions, including rockets, air-launched missiles, mines, and torpedoes, have demonstrated that major hazards also exist when those munitions are subjected to fire conditions for very short periods of time.

On May 24, 1973, a Southern Pacific Transportation Company freight train was approaching Benson, Arizona, when 1 of 12 munitions boxcars in the train caught fire. The boxcars were loaded with 500-pound MK 82 general purpose bombs. As the train stopped, the cargo exploded, and the explosions continued for several hours. The Safety Board determined that the probable cause of the accident was the exposure of heat-sensitive bombs in a boxcar to fire most likely originated from sparks off the brakes shoes which ignited sodium nitrate impregnated floors. As a result of its investigation, the Safety Board recommended that:

--the Secretary of Transportation:

R-75-8

Reassess the regulations applicable to the packaging, loading, storing and transportation of military munitions and develop a safety compliance program to unify and coordinate Federal activities relating to the shipment of military munitions as now authorized by the Transportation Safety Act of 1974.

--the Federal Railroad Administration (FRA) in conjunction with the Secretary's program:

R-75-9

Develop and require the use of a mechanism for the timely detection of fire by crews of trains carrying Class A explosives.

--and that the Secretary of Defense:

R-75-10

Design, develop and use special rail cars for the transportation of military munitions which are constructed of non-combustible materials, or otherwise resistant to ignition from sources external to the car, and reduce or eliminate the use of wooden or other combustible sheathing, blocking and bracing inside the cars.

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Also, as a result of the Benson accident, the Safety Board recommended that the FRA require the (1) use of cars with roller bearings and either composition brake shoes or spark shields in the transportation of munitions, (2) placement of "spacer" cars between cars transporting munitions, and (3) increased inspection and surveillance of freight car loadings in the transportation of military explosives. On November 19, 1974, the FRA promulgated a regulation effective July 1, 1975, establishing new requirements for selection, preparation, inspection, certification, and loading of railcars transporting Class A explosives.

Safety Recommendation R-75-8 was "Closed--Acceptable Action" on October 4, 1982, following completion of the STROM report which included a reassessment of regulations related to munitions transportation. The report also included DOD recommendations to the DOT to authorize cushioned underframe railcars for munitions, to require carriers to remove all hazardous residues from previous cargoes or provide a substitute railcar, and to conduct a study to establish minimum separation distances between munitions railcars, and railcars carrying other hazardous materials.

Safety Recommendation R-75-9 was placed in a "Closed—Reconsidered" status on June 10, 1985. In reconsidering its recommendation, the Safety Board noted that the STROM report indicated that, while a fire detection/suppression system was feasible, it was costly and additional research was needed to determine the capability of the system to perform during train operations and under accident conditions. The DOD, however, suspended further testing. A study initiated at the National Bureau of Standards demonstrated the feasibility of a thermal barrier approach to the protection of a heat-sensitive load from exposure to fire but recommended that additional testing be carried out in full scale. Further tests, however, were not conducted. While further testing in this area might have resulted in some cost-effective approaches to the protection of explosives, particularly with respect to thermal barriers, the Safety Board, in reviewing its position, agreed that the threat of undercarriage fires, had been reduced considerably--boxcars used for transporting explosives must be equipped with metal subfloors or spark shields and high-friction composition brakeshoes and roller bearings—and that measures appear to have prevented any further accidents caused by undercarriage fires.

Safety Recommendation R-75-10 was "Closed" on April 8, 1982, because of operational instructions to properly clean the interior of railcars, the use of all steel boxcars or wood floored cars with spark shields, the requirement of roller bearings, and the reconfiguration of pallets have reduced fire danger. Since 1973, there have been no rail accidents involving the explosion of munitions. The measures appear to have diminished the probability of accidents caused by undercarriage fires.

The STROM report concluded that the DOD's programs to protect munitions from fire focused on the shipboard environment rather than the transportation environment. This appears to continue to be the focus today. The general purpose bombs involved in the Checotah accident were manufactured for the U.S. Air Force and were not covered with a thermal protective coating or any other thermal shielding to increase the cook-off time in a transportation fire environment. Similar, general purpose bombs manufactured for shipboard use by the U.S. Navy, however, are currently covered with a thermal protective coating. Also, while the U.S. Navy proposes to use in the future a new explosive filler in its general purpose bombs that will react less violently when exposed to fire, no comparable change was found for use by the other military services. Furthermore, a summary report of fast cook-off characteristics of air-launched, in-service weapons prepared by the Naval Air System Command's Pacific Missile Test Center in June 1985

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recommended that some weapons be provided thermal protection to delay time to cook off when used aboard carriers. Although the firefighting needs of the U.S. Navy for thermally protected munitions to improve combat ship survivability are valid, the DOD also has a responsibility to minimize the risk of quick cook-off reactions when munitions are transported, not for firefighting purposes but rather to provide critical time for evacuations.

Thermal protective coatings on munitions are not intended to prevent cook-off reactions but instead to delay any explosion for a short period of time. Therefore, the application of thermal protective coating on the bombs involved in the Checotah accident probably would not have prevented the explosions. However, although the persons involved in the accident were able to leave the immediate accident scene before the most violent explosion, the first cook-off reaction occurred only 15 minutes after the accident and while accident vehicle occupants and emergency response personnel were still nearby. Under other accident conditions, the initial cook-off reaction could have been sooner and more violent. The need for additional time to remove victims from accident sites or to evacuate nearby populated areas may be critical. That additional time can be provided by the use of thermal protective coatings or thermal shields/barriers, such as insulated packages, insulated trailers, or insulated rail cars for munitions shipments. Although the Checotah accident did not occur in a heavily populated area, a school building was located only 734 feet away from the accident site. Had the accident occurred while school was in session, the consequences could have been deadly without adequate time for evacuation actions.

The STROM report concluded that the days of minor incidents are gone and that, should an explosion occur today, "things could get serious fast." Yet, the DOD has rejected the use of thermal insulation and fire-sensor-suppression systems as economically impractical in the transportation environment. The DOD's movement toward the use of cook-off-resistant explosives to reduce the fire danger to munitions onboard ships will benefit transportations needs. However, widespread use of explosive fillers in munitions that react less violently in a fire and the modification of weapon designs to meet those goals are many years away. Even then, military services that do not have operational needs to extend cook-off times may not make use of the changes. The DOD cannot ignore the need for thermal protection of munitions shipments in the transportation environment. Instead, the DOD should identify those munitions shipments which pose the greatest threat to public safety in transportation accidents involving fire and should provide thermal protection for those shipments, particularly when the munitions are transported by highway vehicles where munitions may be exposed to the hazard of vehicle fuel fires.

In addition to the Checotah accident, the Safety Board has investigated two other munitions accidents since 1972 where the release of vehicle fuel increased risks of cook-off reactions.

- On August 1, 1984, a tractor-semitrailer transporting Navy torpedoes overturned at the intersection of two major interstate highways near downtown Denver, Colorado. After arriving at the accident scene, the fire department stopped a leak in the vehicle's fuel tank. In its report, the Safety Board found that while no fire resulted during the accident a sufficient volume of diesel fuel was present to have produced temperatures necessary for deflagration of the warheads.

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- On May 10, 1985, a truck-trailer transporting munitions struck a parked vehicle on Interstate 65 near Bonnieville, Kentucky, resulting in a fiery accident. A fuel tank on the truck was torn open and an estimated 30 gallons of gasoline poured onto the ground and ignited. Class A explosives (C-4 plastic explosives) transported in a dromedary on the truck ignited and burned intensely. Although the trailer contained additional Class A and Class B explosive munitions, the fire department chose to deluge it with water rather than withdraw. Fortunately for the fire department, the explosives on the trailer did not explode.

On June 4, 1971, an automobile collided with a tractor-semitrailer transporting non-military explosives near Waco, Georgia. Gasoline and diesel fuel leaked from vehicle fuel tanks, a fire quickly engulfed both vehicles, and the cargo exploded. Two firemen, a wrecker operator, and 2 bystanders were killed as a result of the explosion; 33 persons were injured. As a result of its investigation, the Safety Board recommended that the Bureau of Motor Carrier Safety and the Office of Hazardous Materials in the Department of Transportation:

H-72-31

Initiate appropriate action to develop standards for mandatory installation of fire barriers in trucks or trailers used to transport Class A explosives or other hazardous, heat-sensitive materials. Such standards should apply to future vehicles and, by retrofit, to present vehicles.

The Assistant Secretary for Safety and Consumer Affairs for the DOT responded that there were an estimated 3,000 to 5,000 vehicles owned by large carriers which could be used to transport such materials and that the installation of fire barriers in all vehicles was economically unsound and that the dedication of vehicles could not be justified. The Safety Board reconsidered its recommendation, and no further action was taken at that time. However, as a result of accidents which have occurred since 1972 and the danger that vehicle fuel fires pose to explosives shipments, the Safety Board believes that the DOT should require that Class A explosive shipments by highway be provided thermal protection while in transportation to provide reasonable time for the evacuation of persons in nearby threatened areas.

Emergency Response

Although the accident in Checotah was reported to the fire department as a fuel truck fire, the chief quickly identified a Class A explosives placard on the rear of the semitrailer and withdrew his men to safer locations. It is questionable whether anything could have been done to prevent the bombs from exploding by the time the fire department had time to act, and by the time the chief recognized the need to immediately evacuate the area. His decision to put water on the burning wreckage from a more protected location was to provide additional time for the ambulance attendants to remove victims from the accident scene. However, by the time the third and most violent explosion occurred, the ambulance had been away from the scene for several minutes and the two firemen who were still at the accident scene also should have been withdrawn.

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Additionally, communication difficulties were experienced during the early phases of the emergency response as a result of misinformation and information not being provided in a timely manner to on-scene personnel. For instance, an initial report said that a tank truck was involved in the accident. Later, the police dispatcher failed to inform the fire chief that the truck was carrying bombs. These communication difficulties did not appear to affect the emergency response adversely since the fire chief initiated actions to evacuate the area and to stop rail service on a nearby track as soon as he became aware of an explosive a placard on the semitrailer.

While the shipping papers, which contained important information about the cargo and provided emergency DOD telephone numbers, were not available to emergency response personnel, the Oklahoma Highway Patrol had available and called telephone numbers for the nearest U.S. Army Explosives Ordnance Disposal Unit. That unit, the 61st, provided prompt over-the-phone emergency response information and appropriately responded to the scene.

When emergency response personnel first arrive at accident scenes where Class A explosives may be involved in fire, shipping papers containing critical information about the type and quantity of explosives aboard vehicles and the recommended evacuation distances may not be available. It is therefore important that safe minimum evacuation distances be provided to emergency response personnel in the DOT Emergency Response Guidebook.

While the guidebook currently recommends that a minimum evacuation distance of 2,500 feet be used when accidents involving Class A explosives are engulfed in fire, the DOD has concluded that 2,500 feet is not adequate for truckload and carload shipments of bombs and other large munitions. Based on both fragment and overpressure hazards, the DOD recommends that the minimum evacuation distance in the emergency response guidebook be changed to 3/4 mile (4,000 feet) for highway accidents involving Class A explosives and fire and to 1 mile for railcar accidents. In addition, the American Society for Testing and Materials (ASTM) recommends that emergency response personnel be evacuated a minimum distance of 5,000 feet when Class A explosives are involved in a fire.

Substantial property damage occurred a mile from the accident site where the town's central business district is located. If the accident had occurred during normal business hours, personal injuries probably would have been much greater. The Safety Board does not believe that a minimum evacuation distance of 2,500 feet is adequate for truckload or carload shipments of Class A explosives involved in fire. The DOT, which is currently reviewing the DOD's recommendation to expand the recommended evacuation distances, should increase recommended minimum evacuation distances based on the fragment and overpressure hazards posed by explosive shipments and make the appropriate changes to the emergency response guidebook. In developing recommended safe evacuation distances for explosives that present fragment or overpressure hazards beyond 2,500 feet, the RSPA should strive, wherever possible, to minimize the number of newly introduced evacuation distances. Such action will make it easier for emergency response agencies to train their personnel in recognizing the presence of such materials and in taking appropriate action to protect the public.

Additionally, explosive shipments, which present increased risks because of quantity or special fragment hazards, could be better marked to readily inform emergency response personnel about the need for increased precautions. Such shipments could be identified through a number of ways, including a requirement that explosive placards for increased risk shipments requiring a greater evacuation distance be displayed against a

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square white background, similar to a requirement that placards for highway route controlled quantities of radioactive materials be displayed against a square white background.

CONCLUSIONS

1. The principal threats to the safe transportation of munitions are fire and heat.

2. Thermal protection can delay cook-off reactions for munitions exposed to fire and heat in transportation accidents.

3. Neither the DOT nor the DOD requires that munitions shipments be thermally protected during transportation.

4. If the MK 84 general purpose bombs involved in the Checotah accident had been thermally protected, the explosions would have been delayed, allowing more time to remove victims and evacuate nearby areas.

5. The number of ammunition shipments has doubled since 1980.

6. The DOD does not have in place an adequate munitions transportation safety program to identify unsafe operating practices of motor carriers which transport munitions shipments.

7. The shipment of bombs in the Checotah accident had not been transported over the most direct route between the points of origin and destination, which increased public exposure to the risks associated with the transportation of the shipment.

8. Transit time and routing selection affect public exposure to the risks associated with the transportation of munitions. However, neither the DOT nor the DOD have adequate requirements to minimize in-transit time or the indirect routing of munitions shipments.

9. While the DOD requires that truckdrivers have at least 1 year of driving experience before transporting Class A and Class B explosives munitions, it does not specify that the driving experience be without serious traffic violations or that the experience be recent.

10. Minimum evacuation distances recommended in the DOT's emergency response guidebook were not adequate.

RECOMMENDATIONS

As a result of its investigation, the Safety Board reiterated the following safety recommendations:

— to the U.S. Department of Defense:

Establish Department of Defense safety requirements for the safe transportation of explosive and other high-hazard Department of Defense shipments which motor carriers must meet, in addition to U.S. Department of Transportation requirements. (I-85-25)

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Establish a safety evaluation program to monitor motor carrier compliance with Department of Defense safety requirements for explosive and other high-hazard Department of Defense shipments. (I-85-26)

— to the Federal Highway Administration and the Research and Special Programs Administration:

Amend Federal Motor Carrier Safety Regulation 49 CFR 397.9 to eliminate ambiguities in the routing requirements for vehicles transporting hazardous materials. (H-85-34)

Encourage States to establish through routes for shipments of hazardous materials, and coordinate the compatibility of the designated routes regionally and nationally. (H-85-38)

In addition, the Safety Board made the following recommendations:

— to the U.S. Department of Defense:

Establish more stringent criteria for the selection and continued use of truckdrivers for transporting explosives shipments by increasing the minimum years of recent truck driving experience and establishing minimum training requirements. Also, develop and include criteria for disqualifying drivers based on specific safety violations on driving records, accident experience, and violations of Department of Defense safety requirements. (Class II, Priority Action) (H-87-17)

Implement a program to route expeditiously Class A and Class B explosives shipments over the most direct routes available consistent with public safety and with any unique safeguards required for specific shipments. (Class II, Priority Action) (I-87-1)

Provide thermal protection for those explosives shipments which pose the greatest fragment and overpressure hazards in highway transportation accidents involving fire to allow reasonable time for the evacuation of nearby persons. (Class II, Priority Action) (I-87-2)

Notify the Federal Highway Administration of any safety audit of a munitions carrier which results in the assignment of a safety evaluation other than satisfactory. (Class II, Priority Action) (I-87-3)

— to the Research and Special Programs Administration:

Require thermal protection for those explosive shipments, which pose the greatest fragment and overpressure hazards in highway transportation accidents involving fire, to allow reasonable time for the evacuation of nearby persons. (Class II, Priority Action) (I-87-4)

Quantify, based on tests, the fragment and/or overpressure hazards of Class A and Class B explosives shipments when involved in fire; establish in the Department of Transportation's Emergency Response Guidebook safe evacuation distance(s) for shipments which present these hazards beyond the 2,500 feet presently recommended for all Class A and Class B

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explosives shipments; and require that vehicles transporting such shipments be appropriately identified to readily inform emergency response personnel about the increased hazards and the recommended evacuation distance(s). (Class II, Priority Action) (I-87-5)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JIM BURNETT
Chairman

/s/ PATRICIA A. GOLDMAN
Vice Chairman

/s/ JOHN K. LAUBER
Member

/s/ JOSEPH T. NALL
Member

March 3, 1987

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